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Pressure Safety Standard

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Lawrence Livermore National Laboratory

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Preface

The Pressure Safety Standard is one of several local Lawrence Livermore National Laboratory (LLNL) environmental, safety, and health standards that was prepared during the Work Smart Standards Closure Process to address areas not adequately covered by Department of Energy (DOE) orders or national consensus standards. It was approved on March 23, 1998. Questions or comments about this standard should be addressed to the Technical Support and Policy Development Division Industrial Safety Technical Leader in the Hazards Control Department.

Lawrence Livermore National Laboratory

Pressure Safety Standard

1.0 Introduction

1.1 Purpose

The Laboratory has long recognized the importance of a comprehensive and effective Pressure Safety Program to ensure the safety of personnel, equipment, and the environment. As a research and development contractor for DOE, LLNL develops and uses numerous pressure systems and components. We use national consensus standards where they are applicable, such as for plant facility pressure systems, including boilers, compressed air, and propane storage tanks. However, national consensus standards that are used throughout industry are often not completely transferable to our research pressure systems and work. We have, therefore, adopted applicable methodologies from national standards (see Section 2) and used them as the basis for our own Pressure Safety Standard. This document identifies LLNL's unique pressure vessels and systems and presents the standard we developed for pressure safety.

1.2 LLNL Pressure Safety Program

Our program requires that all pressure vessels and systems be designed, tested, inspected, documented, used, and maintained by qualified and trained personnel in accordance with sound engineering principles, industry standards, and the LLNL standard presented in this document.

This standard applies to all pressure vessels and systems used at LLNL that are not covered by national consensus standards including those purchased commercially as well as those designed, fabricated, or built at the Laboratory. Details about implementing this standard are covered in LLNL's internal safety documents and manuals.

2.0 Applicable Reference Standards

Recognizing that most LLNL pressure systems and vessels are not certified or maintained as American Society of Mechanical Engineers (ASME) code-stamped vessels, we have proactively adopted sound and proven methodology from applicable sections of the following national consensus standards:

- ASME, *Design and Construction of Boilers, Air Receivers, and Pressure Vessels* (1998). Applicable sections may include but are not limited to requirements for materials, design, fabrication, pressure-relief devices, inspection, testing, marking, stamping, reports, and records.
- National Board Inspection Code (NBIC) NB-23 and American Petroleum Institute Code API-510. (1998—These are the same code, published by two different industry groups.) Applicable sections may include but are not limited to inspection and testing of pressure vessels and pressure-relief devices.

We use the ASME code methodology as a guide for establishing rules of safety governing design, fabrication, and inspection during the construction of pressure systems. We also use the NB-23/API 510 code as the guiding methodology for establishing rules of safety governing use and maintenance of our pressure systems, including certification, testing, routine inspection, repair, modification, and procedure tracking.

3.0 Definitions

Pressure Vessel. As part of the LLNL Pressure Safety Standard and Program, "pressure vessel" is defined as a container designed to withstand internal or external pressure above atmospheric pressure. This pressure may be imposed by an external source, the application of heat from an indirect or direct source, or any combination thereof. This container is a relatively high-volume pressure component (such as spherical or cylindrical container) that has a cross-sectional diameter larger than the associated piping or tubing (if any).

Manned-Area Operation. Pressurization in environments where vessel or system failure might cause personal injury. Such vessels or systems have been approved for operation, within specified limits, with personnel present.

Remote Operation. Pressurization in environments where vessel or system component failure would not cause personnel injury. Remote-operation equipment must be installed in test cells or behind certified barricades or be operated from a safe location.

Maximum Allowable Working Pressure (MAWP). The maximum pressure at which a vessel is designed to operate safely. Working pressure, rated pressure, service pressure, and design pressure are the same as MAWP. **NOTE:** The setting of vessel or system pressure relief devices must not exceed this MAWP.

Safety Factor. The ratio of the calculated failure pressure (or actual pressure if known) to the MAWP. A safety factor related to other than the failure pressure should be so identified with an appropriate subscript, that is, Sf_y for a safety factor based on the yield strength of the material, and Sf_u for a safety factor based on ultimate strength.

Ductile Vessel. A pressure vessel fabricated from materials that yield extensively before failure when overstressed at any temperature within the specified working temperature range of the vessel. Materials that exhibit greater than a 5% plastic strain to rupture are generally considered ductile.

Brittle Vessel. A pressure vessel fabricated from materials that do not yield extensively before failure when overstressed at any temperature within the specified working temperature range of the vessel. Materials that exhibit less than a 5% plastic strain to rupture are generally considered brittle.

4.0 Pressure Vessel Design Criteria

The criteria described in this section apply to the design of pressure vessels for manned-area operation. The extent to which these criteria apply to remote vessel operation depends on the required functional reliability.

When designing for normal manned-area operation, a safety factor of 4 is used based on the known failure pressure of the vessel or the calculated stress based on the ultimate strength of the material. A higher safety factor is used if an operation involves detrimental conditions, such as vibration, corrosion, shock, or thermal cycling. A safety factor of 4 or greater must be used when designing a vessel for manned-area operation unless the design complies with the ASME code or a waiver or exemption from this standard is obtained. Pressure vessels containing stored energy above 100 kilojoules (75,000 ft-lb) at their MAWP must be evaluated to ensure that manned-area personnel are adequately protected from the following hazards resulting from pressure vessel failure:

- Shrapnel
- Fragments
- Blast effects
- Fluid jets

Any vessel or system containing hazardous fluids must be designed so that releases of the contained fluid will not pose a hazard to personnel, the public, or the environment.

5.0 Documentation

Design documentation is required if the vessel or system is designed at LLNL. The design documentation shows that every practical precaution has been taken in the design of equipment to control all significant hazards. Design documents are prepared by a qualified pressure designer, reviewed by a qualified LLNL pressure consultant, and approved by the appropriate level of line management. The designer or user must maintain these design documents with the equipment. Design documentation should also be sent to the Engineering Record Center archives.

6.0 Pressure Testing

All pressure vessels or systems designed for operation at LLNL that require documentation must be pressure-tested remotely before being operated in a manned area. Once tested, an LLNL pressure-tested label must be attached to the pressure vessel or system. Documented and labeled pressure vessels or systems and their integral pressure-relief devices must be maintained by the responsible users and inspected by a qualified independent LLNL pressure inspector every three years as recommended by NBIC. Inspection intervals for pressure vessels will be determined using in-service inspection criteria in the NBIC inspection code. Depending on the type of vessel service, the intervals may range from two years to a maximum of ten years. Relief devices on pressure vessels will be inspected every three years. In addition, pressure systems and vessels will be reinspected whenever they are moved or redesigned, or when the application changes, even if the working pressure is reduced.

7.0 Gas-pressure Containment Vessels

Equipment used for protective enclosure of gas-pressurized vessels—including those that contain toxic, radioactive, corrosive, or flammable materials—must be designed to protect personnel from the pressure vessel failure hazards of blast pressure and flying fragments. If hazardous materials can escape from the contained vessel (in case of media leakage), the containment vessel must be designed to prevent subsequent leakage to the atmosphere.

If the contained pressure vessel is of ductile material and has been approved by LLNL for a manned-area MAWP of at least the maximum pressure to which it could be subjected inside the containment vessel, the containment vessel shall be designed to an ultimate or burst safety factor of at least 4.

If the contained pressure vessel has not been approved by LLNL for a manned area MAWP of at least the maximum pressure to which it is to be subjected inside the containment vessel, the containment vessel for manned area operation shall be designed to an ultimate or burst safety factor of at least 8.

8.0 Pressure System Design Criteria for Pipe and Tubing

Pipe and tubing rated at or above the required MAWP must be used. Any modifications to the system that may affect the pressure rating will require calculations by qualified personnel to justify the selection. These calculations must be included in appropriate design documentation.

If the pressure source is not limited to the MAWP of the system, a properly set relief device with sufficient flow capacity must be installed between the pressure source and the system.

Relief devices cannot be isolated from the systems they are intended to protect. Exhausts of pressure-relief devices on systems containing hazardous fluids will be directed to a safe location, ensuring protection for personnel, the environment, and the public.